

**Mine Burial Assessment
State-of the Art in Prediction and Modeling
Workshop and Initiation of Technical Program**

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LONG-TERM GOALS

The ultimate goals are to substantially improve, quantitatively, the U.S. Navy's mine burial predictive capabilities and to provide a strong technical basis for an ONR science program in Mine Burial Prediction in basic and applied research. The goals include technical direction for developing and improving Naval Fleet Aids. The U.S. Navy's capabilities must be substantially improved to meet operational and fleet requirements in mine burial prediction for shallow-water coastal environments.

OBJECTIVES

The objectives followed a sequence of research from a state-of-the-art mine burial prediction assessment through workshops and meetings to the identification of Naval needs and technical requirements and ultimately the initiation of the science and engineering program. An important objective was to synthesize not only past and present methodologies but also to review the deficiencies in predictive techniques and develop recommendations. The objectives were to:

- Review all available currently used technology from national and international sources in countries active in mine burial prediction.
- Identify the most promising approaches and technical expertise to improve *quantitatively* the mine burial predictive capabilities for burial driven by environmental forcing and for seafloor geological materials common in shallow-water coastal environments.
- Complete a comprehensive report on the state-of-the-art in mine burial prediction.
- Plan, develop, and coordinate the science and engineering ONR Mine Burial Prediction Workshop.
- Convene a premiere workshop on mine burial prediction. The task included the completion of a technical report with recommendations.
- Initiate the science program and coordinate technical aspects of the program. This includes:

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- Mine Burial Prediction (MBP) Steering Committee Selection and Coordination
- Establish an Electronic Communication Pathway via the Internet (web site)
- Assessment of the Multi-Piezometer Array System (MPAS)
- Evaluation and selection of potential offshore coastal environments

APPROACH

The approach included many tasks and interrelated objectives identified in the section above to provide a strong comprehensive technical basis for an ONR Program in Mine Burial Prediction. The approach is provided in synoptic form.

- **Review of the Mine Burial Technology.** Included in this task was meetings/communications with CSS, Operational Codes, and appropriate individuals at COMMINEWARCOM in order to ascertain the Fleet requirements in mine burial prediction. This findings and input were used to establish direction, prioritization, and recommendations.
- **NATO Report(s).** Review and analysis of the NATO Mine Burial Specialist Team (MBST) SG-31 activities (NATO Subgroup-31 Analysis and Final Report, 1999) were required.
- **Navy Operational Personnel.** Visit to selected Naval facilities to meet directly with Navy Seals and other “hands on” operational personnel to assess mine burial problems. The objectives were to obtain information on the requirements, difficulties, procedures and recommendations to improve technologies for assessing mine burial operational needs in coastal environments.
- **Extensive Literature Searches.** Comprehensive searches were completed on Mine Burial Prediction, Modeling, and Applied Research, nationally and internationally. This included the convening of a Mini-Workshop in London with European scientist and engineers.
- **Preparation of Comprehensive Technical Report.** Preparation of a major report on the State-of-the-Art in Mine Burial Prediction.
- **Development and Coordination for the Mine Burial Workshop.** This task required technical development of the workshop and communication with national and international scientists and engineers and U.S. Navy Operational Personnel.
- **Convened and Lead Mine Burial Workshop and Prepared Technical Report with Recommendations.** This task included a final technical report with recommendations with the integration of results and findings from the Mine Burial Prediction Workshop and other Mine Burial Assessment Reports (Bennett, et al. 1999a, NATO Mine Burial Prediction Final Report, 1999; Bennett, et al, 1999b, US results of ONR Sponsored NATO Mine Burial Research).
- **Coordination with ONR program managers.** Several meetings were held with ONR managers regarding the workshop report, findings, and recommendations and for definition of technical direction.
- **Initiation and Coordination of the Mine Burial Prediction Science Program.** Following the workshop and completion of the final report, SEAPROBE, Inc. (Richard H. Bennett, P.I.),

initiated the coordination of the science program in Mine Burial Prediction under the sponsorship of the Office of Naval Research. SEAPROBE continues to coordinate the technical aspects of the program.

- **Develop and Coordinate a Mine Burial Prediction (MBP) Steering Committee.** The committee was selected to develop details for the ONR science and engineering program in MBP for review by ONR managers
- **Implement an Electronic Communication Pathway via the Internet (website).** The website is to be used by the Mine Burial Prediction Team, MBP Steering Committee, and ONR during the course of the science and engineering program for information exchange.
- **Conduct a Preliminary Assessment of ONR Field Instrumentation.** The condition of the mechanical, electronic system, and ancillary equipment of the ONR Multi-Piezometer Array System (MPAS) for potential use in the MBP-SP field experiments is being evaluated.
- **Offshore Coastal Environments.** Data are being compiled from relevant sources on the geology, geotechnology, and environmental processes from selected offshore coastal environments. This information will be used for review and evaluation by ONR managers and the ONR scientific program officer (Dr. Roy Wilkens) and the MBP steering committee for selection of potential experimental field sites for mine burial prediction studies.

WORK COMPLETED

The technical work and activities completed and the activities that are presently ongoing in support of the ONR Mine Burial Prediction Program are summarized below.

- 1) Completed comprehensive technical reports:
 - a. Mine Burial Assessment, State-of-the Art, Science, Technology, and Modeling. A review of Coastal Research, Modeling, and Naval Operational Needs in Shallow Water Environments with Recommendations, Bennett, et al., 1999,
 - b. Mine Burial Prediction Workshop Report and Recommendation, Bennett, 2000.
 - c. Mine Burial Prediction Workshop: Technical Program, Agenda, Background, and References, Bennett and Wilkens, 2000.
 - d. Completed Reviews of the state-of-the-art practices in Mine Burial Technology for preparation of the Mine Burial Assessment Report (item 1a above). This included:
 - e. Literature searches, source material identification
 - f. Identification of countries and agencies active in mine burial
 - g. Compilation of a and b
 - h. Review of source materials and technologies
 - i. Contacts/meetings with active technical persons, agencies, etc.
 - j. Evaluation of d and e

- k. Identification of 1) successful methodologies and 2) deficiencies and short-comings
 - l. Synthesis of d, e, f, and g and formulation of initial recommendations
 - m. Reported on findings and recommendations
- 2) Convened the ONR sponsored MBP-SP workshop. SEAPROBE, Inc. A) developed the Purpose Statement for the workshop, B) develop the technical outline, agenda, strategies, plans and goals for the workshop, C) develop and presented to ONR the suggested participants and team leaders, D) conducted the appropriate communications with specialist and proposed teams leaders, E) arrange travel for all ONR sponsored guests, and F) arranged for the meeting location and coordinated lodging and logistics for the workshop.
 - 3) Established the Website for the ONR Mine Burial Prediction Science Program. The website includes references, planning documents, program plans, relevant reports, scheduling, meeting plans, MBP Workshop report, findings, and recommendations and ONR announcements.
 - 4) Identified the potential offshore sites for the MBP-SP and initiated literature searches for the appropriate environmental data required by the program participants. This will include website accessible data and information.
 - 5) Established the MBP-SP Steering Committee in cooperation with ONR Program managers.
 - 6) Initiated the technical evaluation of MPAS (electronic and mechanical components).

RESULTS

Comprehensive technical background is providing the Navy with direction for developing a technical program encompassing the disciplines of marine geology and geotechnique, climatology and meteorology, bathymetry and morphology, modeling and statistics, and mine physical characteristics and behavior in coastal environments to include the science and engineering applications for the Fleet and Operational Navy personnel. An initial ONR science and engineering program plan is now being developed with a two-prong effort; one in basic science and one in applied science. The following narrative reviews the essential requirements established for the Mine Burial Program.

A close interaction among the scientific and engineering community and Navy operational personnel is required throughout the duration of the MBP Science Program. This will be accomplished by the interaction of the Steering Committee with key ONR, NAVOCEANO and COMINELWARCOM technical staff. The steering committee will provide an important interface and technical link between the operational navy and the science and engineering community involved in the Mine Burial Prediction Science Program. ONR will have oversight of the program.

New advances in the state of knowledge of bottom boundary layer dynamics, hydrodynamics, sediment dynamics, marine geology and geotechnology, instrumentation, computational fluid dynamics, and coastal oceanography will provide substantial improvement in mine burial prediction. The MBP basic research program will integrate field, laboratory, and statistical studies with theoretical modeling to support the transition of results to the operational navy. The comprehensive science and engineering program in mine burial prediction will require an interdisciplinary team effort focused on

the complex coupled interaction of environmental forcing on the seafloor-mine system by waves, currents, tides, and gravity.

In order to predict the behavior of mines the three essential elements are:

- A) Accurate predictions of the fluid forces, including waves, bottom boundary layer, currents and bottom pressures, surf conditions, and inshore currents, and
- B) the geotechnical properties of the sediment in the vicinity of the mine; and
- C) the magnitude and seasonality of regional-scale changes in the morphology of the seabed.

The program will require expertise in bedform migration, scour and sedimentation, impact burial, geotechnical properties and processes, coastal processes, climatology, numerical and analytical modeling, statistics and probability modeling, instrumentation, geological and geotechnical proto-type mapping, and large-scale laboratory studies. Upgrading and development of new mine burial models requires comprehensive knowledge of seafloor properties and processes as well as mechanisms that drive mine burial in coastal environments. Detailed data on the statistical distribution of sedimentological/geotechnical properties are required. Well-planned field and laboratory experimentation addressing environmental processes, seafloor sediment variability, and coupled processes is of paramount importance. Input from the operational navy will provide a strong underpinning for the success of the program.

IMPACT/APPLICATIONS

A substantially improved quantitative capability for the U.S. Navy's Fleet and Operational Forces is anticipated. The mine burial predictive capabilities will provide a strong technical basis for enhancing the U.S. Navy's capabilities and fleet requirements in mine burial prediction for coastal environments not only for domestic applications but also for international scenarios. The goals include the improvement of Naval Fleet Aids.

TRANSITIONS

The ONR Mine Burial Prediction Program will integrate field, laboratory, and theoretical modeling with statistical, scientific and engineering contributions, to advance the state-of-the art in mine burial prediction and support transition of scientific results to applied problems for the operational navy.

RELATED PROJECTS

Numerous projects of sediment transport processes, marine geology, and oceanography are ongoing that focus on questions fundamental to mine burial. In the USA, the ONR Programs in Geology and Geophysics and Coastal Dynamics support and coordinate basic and applied research in the field of shallow-water sediment transport processes, and geology and geophysics of the continental shelves. Other organizations are collaborating in the ONR programs including coastal geologists from the US Geological Survey, coastal engineers from the US Army Corps of Engineers, and university scientists involved in National Science Foundation research grants. The Naval Coastal System Station (NCSS) staff scientists and staff scientists at the Naval Research Laboratory and Scripps are conducting mine burial tests. The mine burial work at NAVOCEANO includes extensive effort in the development of surficial geology maps of selected coastal areas of the world. These maps depict the sediment and

other geological material types from the shoreline to water depths of 200 meters. The Office of Naval Research has contributed to the NATO SG-31 Mine Burial Studies and Field exercises off the coast of Holland in 1977. Continued NATO Mine Burial Studies are presently in discussion with European allies.

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